Classroom Activities

The Astronaut Game

Subject: Communications
Topic: Human space spaceflight
Description: The need for accurate communications in manned spaceflight is demonstrated with a simple game involving paper and pencil.
Contributed By: Dr. Harry B. Herzer, III, HQ (adapted from an activity by the same name)

Materials:

Pencil or marker pen and a clean sheet of paper for each team of 4 students
Copy of the artwork on the next page for each team

Procedure:

1. Divide students into teams of 4 or 5.

2. Instruct each team to assign team members to the following jobs:

   Astronaut
   Communication Satellite
   Tracking Station
   Data Relay System (if team has five members)
   Mission Control

3. Explain to each team that a manned landing on the Planet Mars has taken place. Unfortunately, a malfunction in the landing craft's television transmission system has developed preventing scientists on Earth from seeing pictures of the Martian terrain. The scientists request the astronauts on the planet to describe what they see outside their spacecraft.

4. Give the designated Astronaut a copy of the picture of the Martian terrain. Instruct the astronaut to show it to no one.

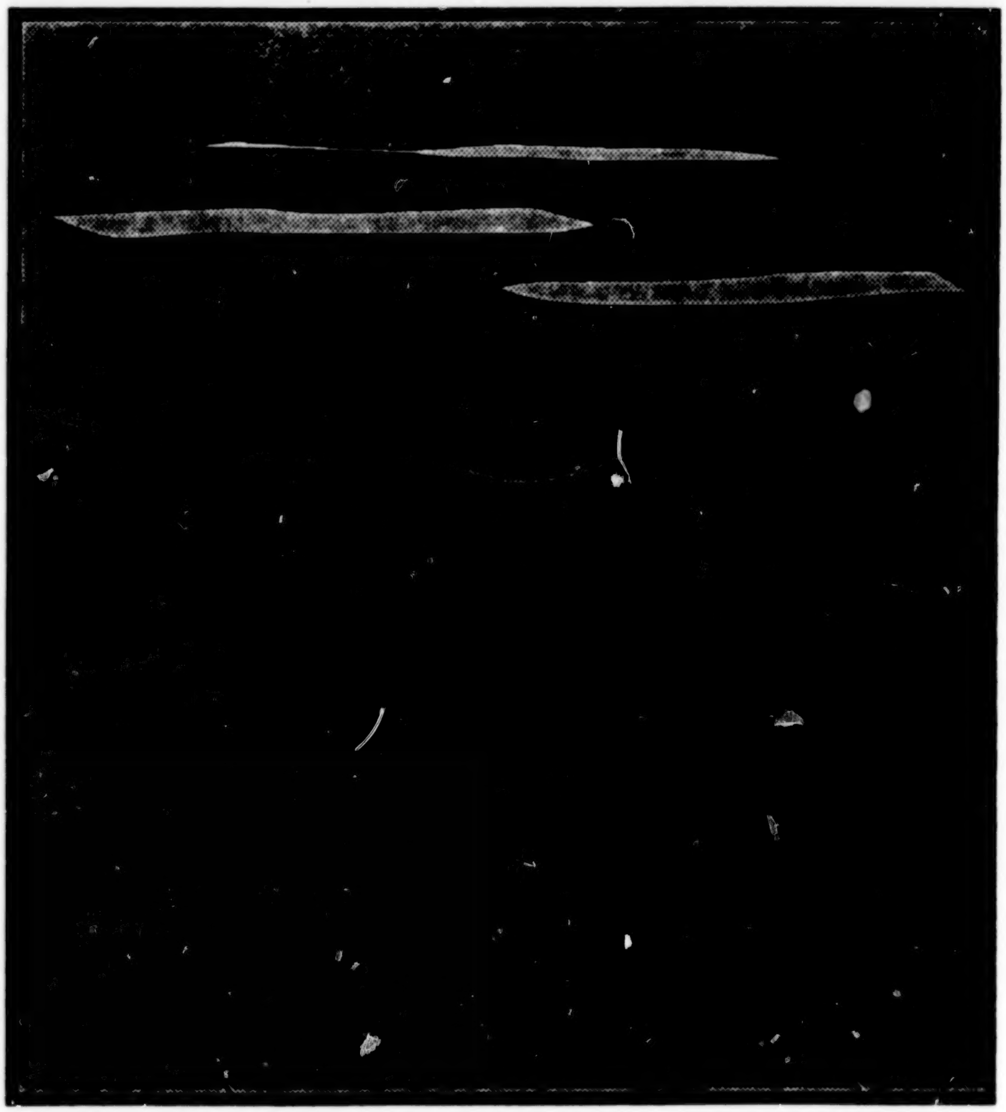
5. The Astronaut begins the activity by verbally describing some of the things seen in the picture to the Communication Satellite. The description should be whispered so that none of the other team members can hear it. The Communication Satellite relays the description to the Tracking Station who in turn relays it to the Data Relay System or directly to Mission Control. While the first message is being received by Mission Control, the Astronaut sends more information until the entire picture is described.

6. As the descriptions are received by the Mission Control team member that person uses a pencil or marker pen to sketch a picture of the Martian terrain on a sheet of paper.

7. Conclude the activity by giving everyone a chance to compare the original picture with the one drawn by Mission Control.

Discussion:

Accurate communication is imperative for spaceflight. Much time and effort is wasted if communications are ambiguous. Critical mistakes can be made if messages are misunderstood. Consequently, NASA astronauts and mission controllers train extensively with each other before the actual mission to insure that each are fully fluent with terminology. To save time, many descriptive words and phrases are reduced to acronyms such as RMS for remote manipulator system, MECO for main engine cutoff, and PLSS for portable life support system.



Mars Horizon

Classroom Activities

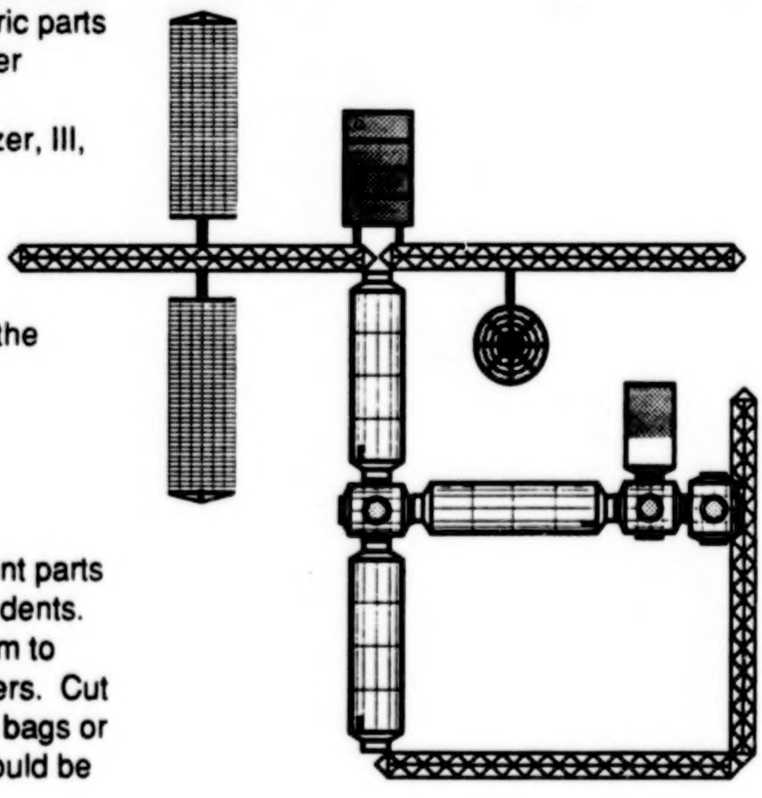
Design Your Own Space Station Communications Exercise

SUBJECT: Communications and Space Station
TOPIC: Designing a layout for a space station design and communicating this information accurately to a colleague.
DESCRIPTION: Students attempt to build matching space stations from generic parts while communicating with each other through verbal channels only.
CONTRIBUTED: Dr. Harry B. Herzer, III, HQ

MATERIALS:
Space station component parts
Zip-lock bags or envelopes to hold the component parts
Glue
Scissors

PROCEDURE:

1. Copy the space station component parts to make enough sets for your students. Reinforce the parts by gluing them to heavy paper such as old file folders. Cut out the pieces and place them in bags or envelopes. Each set of parts should be identical.
2. Divide your students into groups of two or four students each. Split each group in half into subgroups and give each a set of space station components.
3. One subgroup begins the activity by laying out the component parts and arranging them into a space station of their design. The other subgroup should be positioned so that they cannot see the design.
4. The first subgroup then tries to get the second subgroup to duplicate the space station design by giving them verbal instructions only.



5. After the second station has been created, permit both groups compare their efforts.
6. Reverse roles and tell the second sub-

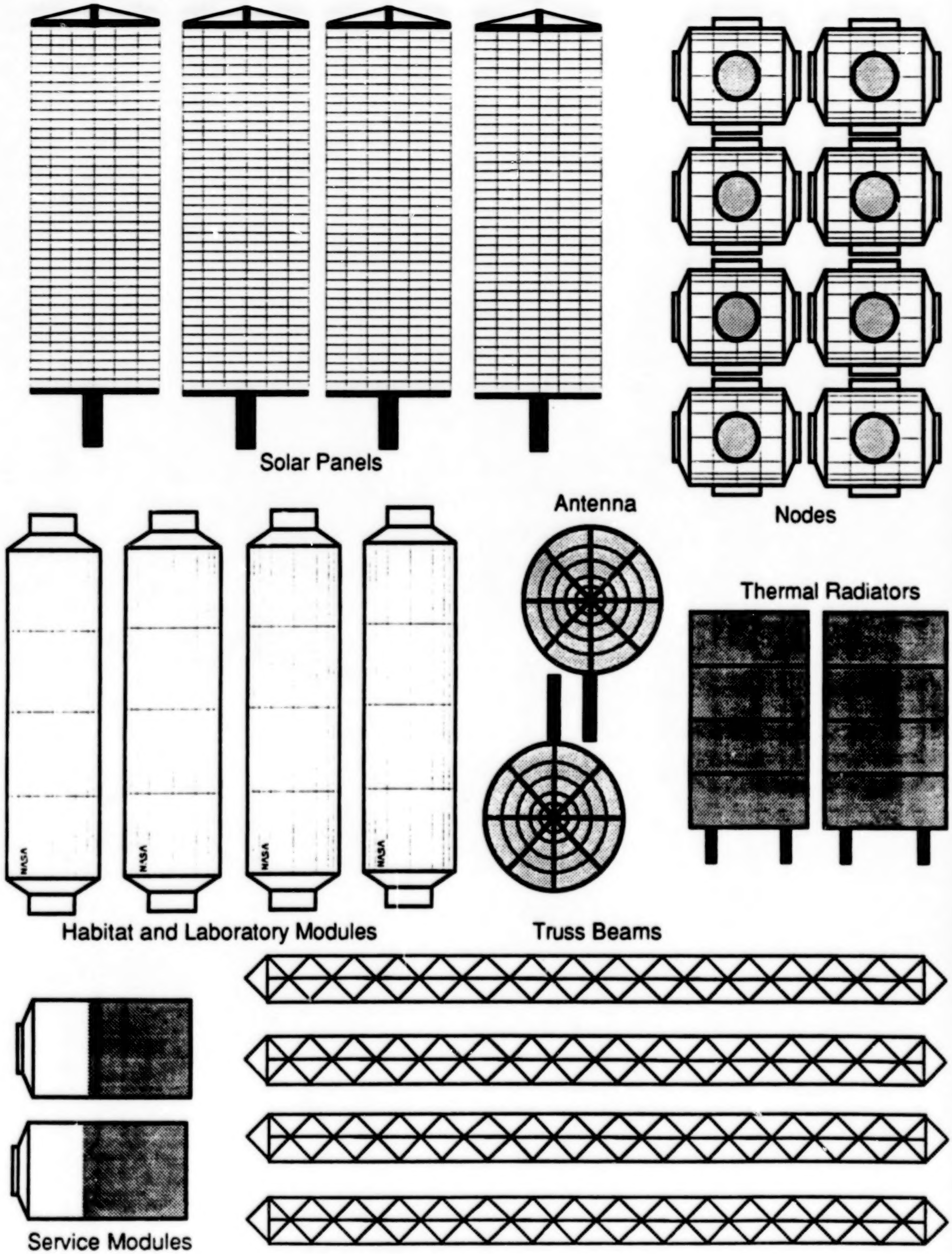
group to design a station and verbally communicate the design to the first.

7. (optional) To assist in preparing students for this activity, you may wish to make view graphs of the station modules to demonstrate what will be reguired.

DISCUSSION:

This activity provides an excellent introduction to the problems of spaceflight communication. When only words are permitted, as in radio communications, they have to be very precise. Students will discover, as they become more experienced with the activity, that they will be creating words to describe components of the space stations they are building. Not only do the words used have to be precise but the directions also. Statements like "take the thingmajig and place it right over there" are meaningless. More precise and useful are statements such as "position the module so that its right end is in direct line with the left end of the module you placed down before."

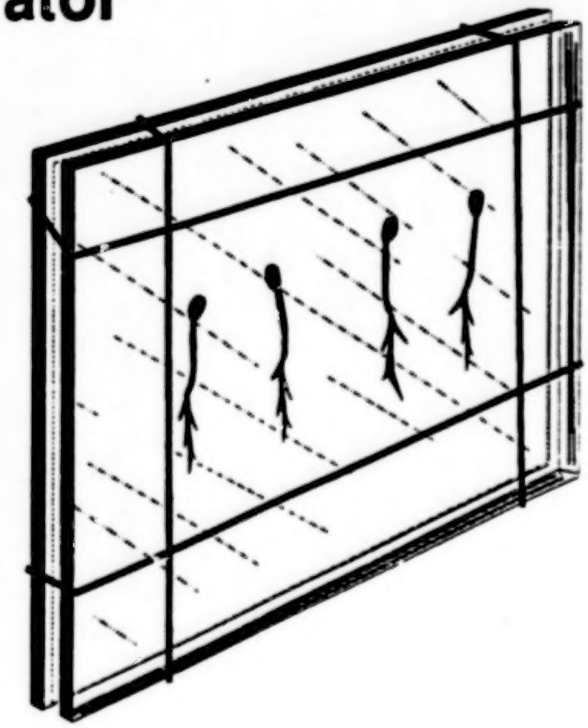
As an interesting variation of the activity, imagine the two subgroups are located great distances apart such as on Earth and in orbit about Mars. Under such a circumstance, cross communication is very difficult. An instruction by radio takes 20 minutes to get to Mars. A question regarding that instruction will take another 20 minutes to get back to Earth and still another 20 minutes for the answer to return. Unless communications are very precise, much time will be wasted.



Aerospace Education Services Project
Oklahoma State University

Classroom Activities

Geotropism Demonstrator



Subject: Plant Tropisms
Topic: Geotropism
Description: Seeds are germinated in a transparent growth chamber and are later inverted to show geotropism.
Contributed By: Gregory Vogt, OSU

Materials: (per growth chamber)
2 Sheets of plastic window pane 6" by 6"
Paper towels
Garden seeds (beans, peas, radishes, etc.)
Dish pan or other tub
Scissors
Water
Rubber bands (4)
Emery paper (fine)

Procedure:
1. Smooth the edges of the plastic sheets with emery paper.
2. Cut 4 squares of paper towel 6" by 6" in size.
3. Lay down a sheet of glass. Place the towel squares on top of the panes. Place four seeds in a row across the middle of the towels about 1 inch apart from each other. Lay the second pane on top of the pile.
4. Secure the panes together by looping four rubber bands around them as shown in the illustration.
5. Stand the edges of the panes in the dish pan so that the seeds are arranged horizontally. Add about 1 inch of water to the tub and keep it filled to that level.
6. In a few days to a week or so, when stems and roots of the plants are about 1/2 to 1 inches long, turn the panes upside down to invert the plants. Observe new growth patterns over the next several days.

Discussion:
Due to capillary action and the absorbancy of the paper towels, water is carried up to the seeds to permit them to germinate. In response to the effects of gravity, the seedling's stems grow upward and the roots grow downward. By inverting the growth cell, the direction of gravity for the seedlings

has been changed. Stems and roots continue to respond to gravity and reverse growth direction. Seedlings that are turned on their sides will make right angle turns to respond to the the new direction of gravity.

Plant responses to gravity are thought to be the result of variable growth due to the accumulation of growth hormones. Inverting or setting plants on their sides redistributes growth hormones. Hormones accumulate in low spots within plant tissues. In roots, the growth hormones retard growth along one side. Continued growth along the other side causes a bend in the direction of the roots back to the downward position. In stems, accumulations of growth hormones accelerates growth causing a redirecting of the stems upward.

Plants grown on orbiting spacecraft do not receive gravity clues. Orbiting spacecraft are in a continual state of free-fall which negates gravity effects. Plant parts grow in haphazard directions. In many space experiments on plants, roots have been seen to grow in the same direction as stems. Lignin, the supportive tissue in plant stems that permits stems to stand upright, has been observed to be reduced by as much as 15% in space-grown plants.

Astronauts, living on future space stations and space ships heading to other planets, will come to depend upon plants as sources of food, for atmospheric and solid and liquid waste treatment, and as aesthetic links to Earth. Long-term plant growth and effective production may require artificial gravity to be generated onboard. This can be accomplished by changes in velocity or direction that produce forces, resembling the effects of gravity, to be exerted to be on plants. Continuous velocity changes can be achieved in interplanetary space ships through prolonged acceleration or deceleration. Eventually, however, the acceleration or deceleration must stop or the space ship will miss its target. Continuous rotation of a space station, or at least of plant growth chambers can produce long-term gravity-like effects. Rotation can also be employed on interplanetary space ships. Like swinging a bucket of water over your head, rotation in space will cause plant stems to grow inward and roots to grow outward.

Classroom Activities

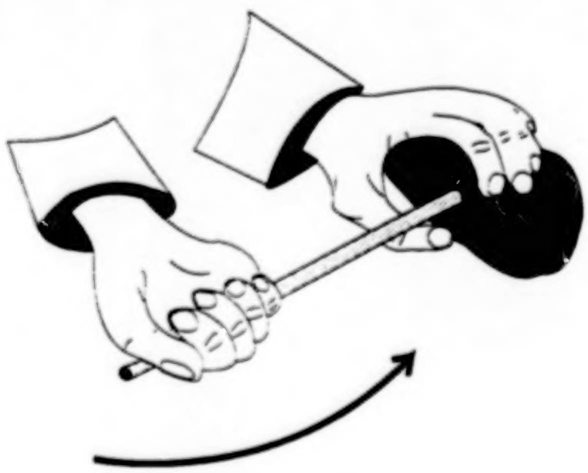
METEOROIDS

SUBJECT: Manned and Unmanned Space Exploration
TOPIC: Meteoroids
CONTRIBUTED BY: Jack Bannister, GSFC
DESCRIPTION: The penetrating power of a projectile with a small mass but high velocity is demonstrated.

MATERIALS:
Raw baking potato
Large diameter plastic straw

METHOD:
1. Hold a raw potato in one hand. While grasping the straw with the other hand, stab the potato with a quick, sharp motion. The straw should penetrate completely through the potato .
2. Again hold the potato and this time stab it with the straw using a slow push. The straw should bend before penetratingthe potato very deeply.

DISCUSSION:
Astronauts traveling great distances in space are likely to encounter fast moving particles called *meteoroids*. A meteoroid can be very large with a mass of several thousand metric tons or can be very small *micrometeoroids* about the size of a grain of sand. Every day the Earth is struck by hundreds of thousands or even millions of meteoroids but most are micrometeoroids that never reach the Earth's surface because they are changed to gases by the intense heat that is generated when they rub against the atmosphere. It is rare for a meteoroid the size of a baseball to enter the Earth's atmosphere (becomes a *meteor*) and rarer still for one to be large



enough to actually survive the descent through the atmosphere to reach the solid Earth. Such a particle is called a *meteorite*.

In space there is no blanket of atmosphere to protect spacecraft from the full force of meteoroids. It was once thought that meteoroids traveling at velocities averaging 80 kilometers per second would provide a great hazard to spacecraft. Scientific satellites with meteoroid detection devices proved, however, that the hazard was minimal. The chances of a spacecraft on the way to the Moon of being struck by a walnut-sized meteoroid were

about 1 in 15,000. The majority of meteoroids are too small to penetrate the hull of spacecraft. Their impacts may cause pitting and sandblasting of the covering surface of spacecraft that eventually change the heat radiating properties and solar panel performance of the spacecraft.

Spacecraft engineers have learned a number of ways to protect spacecraft from micrometeoroids including constructing double-walled shields. The outer wall, constructed of foil and hydrocarbon materials, disintegrates the striking micrometeoroid into harmless gas that disperses on the second wall.

Classroom Activities

Pop Bottle Space Station

SUBJECT: Space Stations
TOPIC: Construction
DESCRIPTION: A large space station model is constructed out of two-liter plastic soda pop bottles and various hardware and scrap items.
CONTRIBUTED BY: Gregory Vogt, JSC

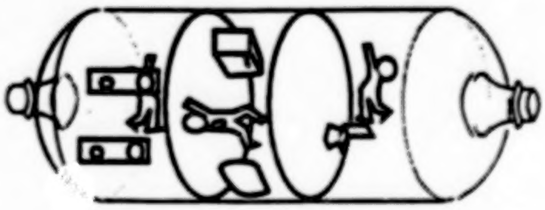
MATERIALS and TOOLS:

Two-liter soda pop bottles (two per module)
Plastic hose connectors (from hardware store)*
Assorted dowel rods*
Plastic meat trays
Cellophane tape
Scissors
Razor blade knife
Miscellaneous "junk"

*Plastic hose connectors come in many sizes and shapes. Choose some that will either snugly fit inside the pop bottle pour spouts or fit around the outside. Sand paper or a file can be used to reduce the diameter of the pour spout to make the fit if necessary. Select dowel rods to fit the connectors to provide extensions for mounting solar panels, heat radiators, and antennas.

PROCEDURE:

1. Cut the pour spout end off of one of the two pop bottles collected for each module as shown in the diagram. Tape this end

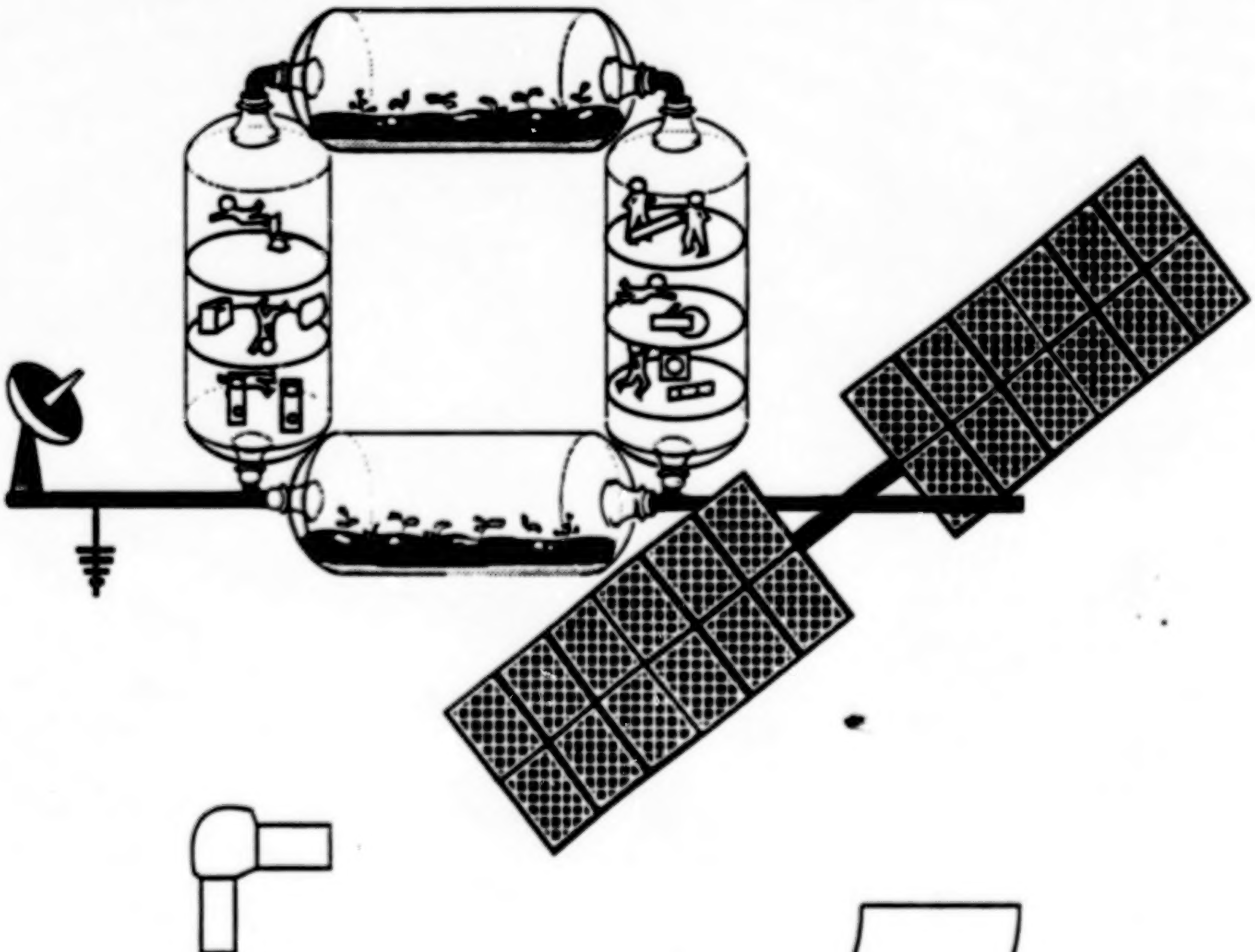


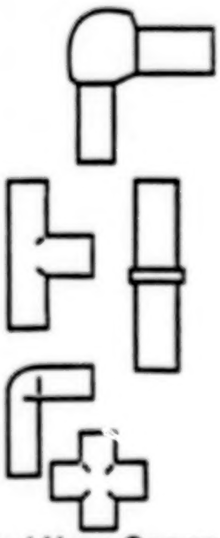
to the rounded bottom of the other bottle so that the module appears to have two pour spouts. Make at least four modules per space station model.
2. Join the modules together in any design you wish with the hose connectors.
3. Add solar panels made from plastic meat trays, antennas from paper cups, the bottoms of soda pop cans, or anything else your students come up with.
4. To add extra interest to the model, cut doors in the modules with the razor blade knife and add furnishing to the modules. Partitions from plastic meat trays can be taped in place or held with glue. Small toy human figures can be added. Use one module as a terrarium. Add aquarium gravel to its bottom and cover with soil mixed with charcoal. Plant small-growing plants and water. Be careful not to over water. Shortly, water drops will condense on the walls of the bottle and run down the sides to form a mini hydrologic cycle.
5. Assemble the model on a table top or suspend with many strings from the ceiling.

DISCUSSION:

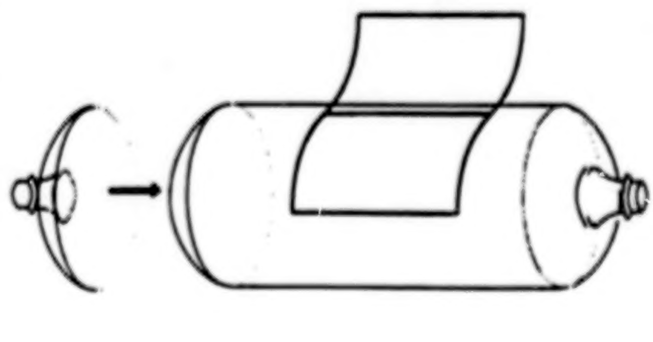
The soda pop bottle space station model is one of many variations of "junk" spacecraft model activities. Have students explain the design of their station to students in other classes and to parents during open house. Consider story-writing activities that explain how a real version of their station would be constructed in space and what would take place on board it.

Soda Pop Bottle Space Station





Typical Hose Connectors



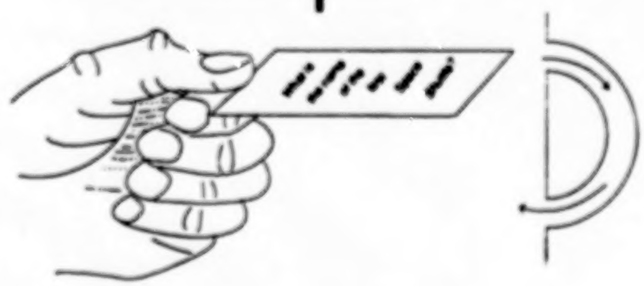
Oklahoma State University

Classroom Activities

Shuttle Chute

SUBJECT: Manned Spaceflight, etc.
TOPIC: A simple question and answer device is constructed for or by elementary students.
DESCRIPTION: Students try to answer questions on cards and then read answers on the card backs after the cards have been fed through the Shuttle Chute.
CONTRIBUTED: Janifer Mayden, NASA HQ

MATERIALS:
Half gallon milk carton (paper)
Tape
File cards
File folder
Scissors
Decoration materials

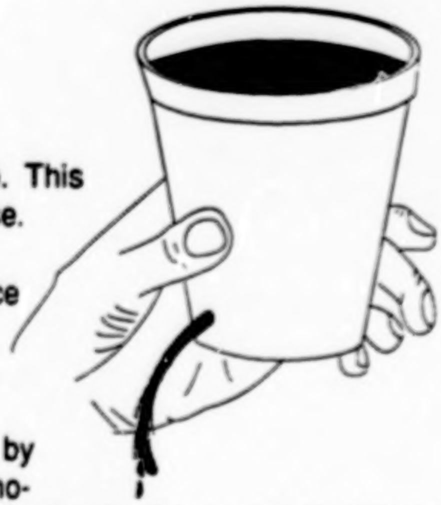


PROCEDURE:
1. Cut open one side of the milk carton to access its interior.
2. Cut two rectangular openings in the other side of the carton as shown in the diagrams.
3. Cut two strips of heavy paper from the file folder and bend them into semicircles. Fold the ends of the paper to form tabs for taping. The strips should be wider than the rectangular holes cut in step 2. One strip should be longer than the other as shown in the diagrams.
4. Tape the strips around the rectangular holes as shown in the diagram.
5. Seal the back of the milk carton and decorate the milk carton to look like a Space Shuttle.
6. Make up a few dozen question cards about the Space Shuttle or any other outer space topic you choose. Write the questions on one side of each card and the answers on the other.

USING THE SHUTTLE CHUTE:
Students should read the questions on the cards and try to answer them. Each card is slipped into the top rectangular hole. The heavy paper strips inside bend the card and invert it before it comes out the lower rectangular hole. The answer to the question becomes visible as the card leaves the chute.

Classroom Activities

Zero-G Demonstrator



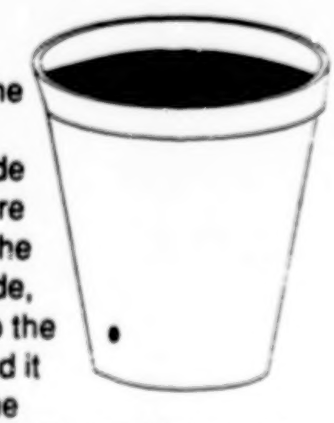
SUBJECT: Space Flight
TOPIC: Free fall
DESCRIPTION: A water stream coming out of a hole in a styrofoam cup stops when the cup is dropped.
CONTRIBUTED BY: Dale Bremmer, HQ

MATERIALS:
Styrofoam coffee cup
Pencil or other pointed object
Water
Bucket or other water catch basin

PROCEDURE:
1. Punch a small hole in the side of a styro foam cup near its bottom.
2. Hold your thumb over the hole as you fill the cup with water. Ask students what will happen if you remove your thumb.
3. Remove your thumb and let the water stream out into the catch basin on the floor.
4. Again seal the hole with your thumb and refill the cup. Ask students if the water will fall out of the hole if you drop the cup as you remove your thumb.
5. Drop the filled cup into the catch basin. The demonstration is more effective if you hold the cup high before dropping it.

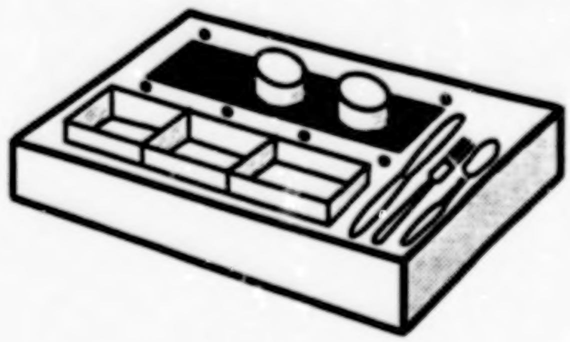
DISCUSSION:
Zero-G that astronauts experience inside the Space Shuttle is really not zero-G at all. Zero-G implies that gravitational pull in space is zero. This is not the case. Astronauts "float" in space because they are in a state of free fall produced by their orbital motions around the Earth. Astronauts and their spacecraft are falling together. The condition is better described as "weightlessness" because a bathroom scale inside the Shuttle would not record any weight for an astronaut standing on it. The scale would be falling too.

The falling styrofoam cup demonstrates weightlessness (or zero-G) for a brief period of time. When stationary, water freely pours out of the cup. If the cup falls too, the water remains inside the cup for the entire fall. Even though the water remains inside, it is still attracted to the Earth by gravity and it ends up in the same place that the water from the first experiment did.



Classroom Activities

Space Food Tray



SUBJECT: Manned Space Flight
TOPIC: Food systems
DESCRIPTION: A working replica of the Space Shuttle food tray and food packages are made from a cardboard box and plastic freezer containers.
CONTRIBUTED BY: John Hartsfield, LeRC

MATERIALS:

Federal Express Overnight Box (or other cardboard box 18 X 12 X 3 inches in dimensions)
Plastic Canvas 13 X 6 inches (for needle-point)
Silver foil wrapping paper (enough to cover the box)
8 Brass paper fasteners
Styrofoam sheet 18 X 12 X 2 inches
Liquid nail (or other glue that will bond styrofoam to cardboard)
Rubber cement
6 Velcro patches (from hardware or fabric store)
3 Pint size plastic freezer boxes
Cellophane tape
Plastic flatware (knife, fork, and spoon)
Assorted dry foods
Pudding or fruit cups (commercial food product in aluminum cans with pull-back lids)
Water

PROCEDURE:

1. Cut two rectangular openings in the box as shown in the picture. The openings should be just large enough to fit three plastic freezer boxes snugly.
2. Trim the styrofoam sheet to exactly fit the inside of the box.
3. Glue the styrofoam sheet to the inside of the box opposite the side the openings are cut. Close up the ends of the box and glue or tape them shut.
4. Carefully wrap the foil completely around the box and tape into place forming neat corners. The long seam should be positioned on the side opposite the openings. For a smoother finish, use rubber cement to bond the wrapping paper to the box.
5. Take a knife or scissors and cut the paper over the openings as shown in the diagram so that the paper will neatly fold around the edges and then tape it to the inside of the box.
6. Punch 8 holes as shown in the diagrams for the brass paper fasteners.

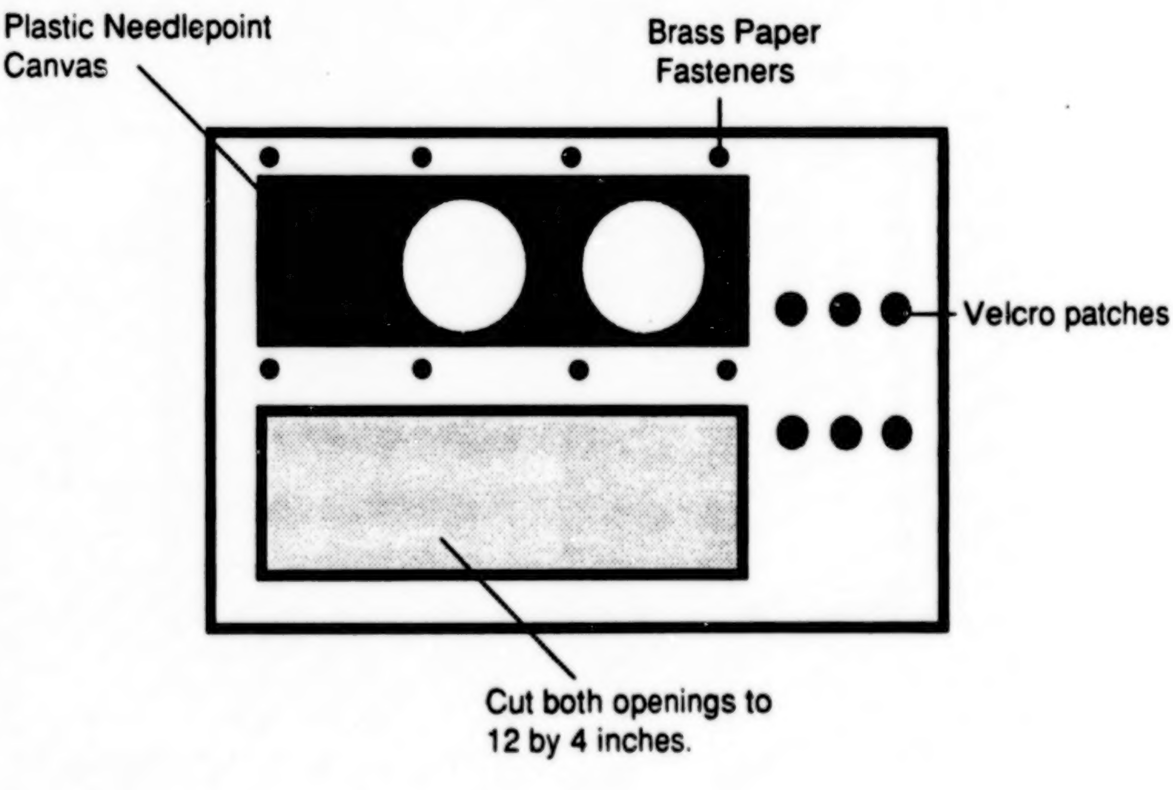
7. Cut the plastic canvas lengthwise and then cut two round holes just large enough to hold the aluminum cans.
8. Attach the canvas to the inside of the box as shown in the diagram with the paper fasteners. Bend the fasteners to hold the canvas snugly.
9. Attach velcro patches to the backs of the plastic flatware and the corresponding wool patches to the food tray as shown.

ACTIVITY IDEA:

Make up several food trays and place various commercial food items in the freezer boxes. Use foods like dry soups, cereals, and freeze-dried fruits and vegetables. Many of these foods are available from supermarkets or from camping supply stores. Have your students prepare the foods with the addition of water and then simulate a meal in space. While eating the food, discuss problems astronauts might have eating in space. What happens to spills? How does the food stay in the food boxes? How do the astronauts clean up after their meal?

DISCUSSION:

The Space Shuttle food system is designed for convenience and versatility in the apparent weightless condition of Earth orbit. Once food items have been prepared by the addition of water and heating (if necessary), individual food boxes are inserted in the slots of the tray. The tray can then be mounted to one of the orbiter's cabin walls or strapped to a crew member's lap for stabilization and easy eating.



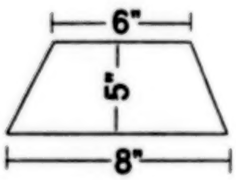
Classroom Activities

Vertical G-Meter

SUBJECT: Manned Space Flight
TOPIC: Gravity forces produced by acceleration and deceleration during rocket launch, orbital velocity changes, and reentry.
DESCRIPTION: A simple meter is constructed that can be used to make approximate measurements of G-forces.
CONTRIBUTED BY: Gregory Vogt, OSU

MATERIALS:

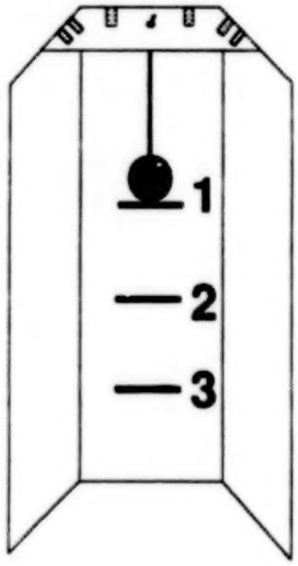
- 1 sheet of white poster board
- 1 long and thin rubber band or a rubber strand from a paddle ball
- 3 solid rubber balls
- Scissors
- Marking pen
- Tape
- Ruler
- Stapler



Top

PROCEDURE:

1. Measure and draw a square 18" by 18" in size on the poster board. Divide the square into three parallel rectangles 6" by 18" in size. Cut out the square and fold on the inner lines to form a u-shaped trough.
2. Measure and cut a trapezoid as shown in the figure.
3. Tape the trapezoid to one end of the trough as shown.
4. Staple one end of the rubber strand to the ball.
5. Punch a hole through the trapezoid as shown and thread the other end of the rubber strand through it and tie a knot. The ball should hang about half way down the trough when the trough is standing upright.
6. Mark the position of the bottom of the ball on the poster board. This indicates an acceleration of 1-G (1 times the force of gravity).
7. Temporarily attach a second ball to the first and again mark the position of the bottom of the ball on the poster board. The addition of the second ball simulates the effect of a 2-G acceleration (or deceleration). In other words, the second ball simulates how much the first ball would weigh under this condition.



8. Add a third ball to simulate 3-G and mark its position on the poster board. Remove the extra balls. The G-meter is ready.

MEASURING G FORCE

The best place to use your G-meter to measure G force is on a roller coaster. Hold it steady as you ride around the track. The ball (or lead weight) will respond to changes in motion by moving up or down. At the bottom of a dip, when the car starts back up, the ball will be pulled downward and may reach the 2 or 3-G mark. Actually, the ball is not being pulled down at all. Read the discussion section for an explanation of what really happens. At the top of an incline, when the car suddenly dips down, the ball appears to be pulled up. If it reaches a point where the rubber band is slack, you are experiencing zero-G. If the ball bounces against the top of the poster board frame, you are experiencing negative Gs.

A fast elevator is also a good place to use your G-meter. Brace the meter against a wall to keep it from slipping as the elevator car moves. Still another place to use the G-meter is simply to hold it next to your chest and jump up and down. Have someone else watch you to read the G-meter for you.

DISCUSSION:

All objects have in common the property of inertia. Inertia is a resistance to change in motion. You feel inertia in your stomach when you ride a fast elevator or go over a sharp dip in a country road. The inertia of astronauts on liftoff causes their bodies to resist the upward climb into space. As their rocket accelerates upward, astronauts are pushed back into their seats. They feel heavier. Actually, it is their inertia that tries to hold them in the same place as the seats push upward against them. During this upward acceleration, the astronauts go through a range of G forces. G stands for gravity. When they are accelerating fast enough, so that their bodies feel twice as heavy as they normally do, they are experiencing a 2-G acceleration. On reentry, space vehicles have to slow down (decelerate) and again, astronauts are pushed into their seats so that they feel heavier than they normally do on Earth. In orbit, however, astronauts do not feel the sensation of gravity because of their apparent weightlessness caused by the free fall of their spacecraft around the Earth. Sometimes astronauts call this condition "zero-G" but this is not a good term to use because it implies gravity is zero. The gravity is actually there (what else would keep the spacecraft in orbit instead of spinning off into space?) but free-fall masks the sensation of it. Small gravity-like sensations can be felt by astronauts as they fire reaction control rockets and orbital maneuvering system engines to change their attitude or velocity in space. Again, the astronaut's inertia causes them to resist the change in motion and they consequently feel a gravity-like pull. Often, this pull is very slight and it is called "microgravity."

G-meters (accelerometers) can sense the change in the apparent gravity force caused by changes in motion in the same way your stomach senses movement. The inertia of a weight inside the G-meter causes it to resist motion changes. The resistance is read as G force with the measuring scale. In the case of the vertical G-meter, the suspended ball seems to move up or down in opposition to the up or down movement of the cardboard frame supporting it. The vertical/horizontal G-meter in the companion activity does the same but because of its design, it can also sense horizontal movements.

Note: The Vertical G-Meter is based on an activity from Dr. Carolyn Sumners of the Houston Museum of Natural History.

Classroom Activities

Vertical/Horizontal G-Meter

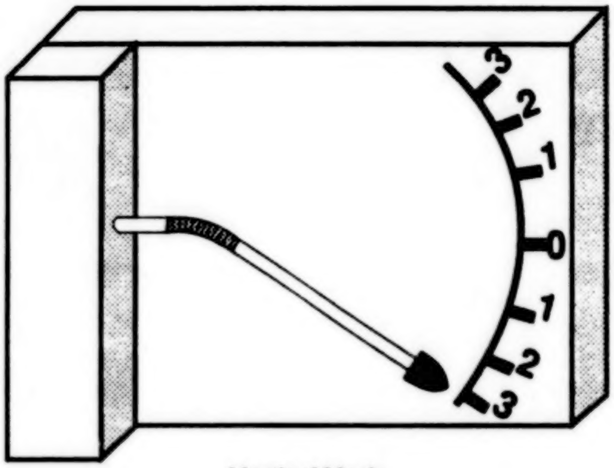
SUBJECT: Manned Space Flight
TOPIC: Gravity forces produced by acceleration and deceleration during rocket launch, orbital velocity changes, and reentry.
DESCRIPTION: A simple meter is constructed that can be used to make approximate measurements of G-forces.
CONTRIBUTED BY: Gregory Vogt, OSU

MATERIALS:

1 board 12"x15"x1"
1 board 12"x2"x1"
1 3/16" or 1/4" dowel rod
1 compression spring (the spring should fit snugly over the end of the dowel rod and not be very stiff.)
3 fishing sinkers (about 1/2 ounce each. Worm sinkers have a pointed shape on one end and make good pointers.)
Drill and bit
Wood glue and screws or clamps

PROCEDURE:

1. Drill a hole in the middle of the edge of the smaller of the two boards. The hole should be just large enough to insert a short (about 1 1/2 to 2 inch) piece of dowel rod into it.
2. Glue and screw or clamp (until the glue is dry) the small piece of wood into the other board as shown.
3. Slide one end of the compression spring onto the dowel piece.
4. Cut 3 pieces of dowel rod 9 inches long.



Vertical Mode
3-G Liftoff

5. Carefully drill short holes into the 3 fishing sinkers. Hold the sinkers in a vice when you drill them. Insert one dowel rod into each sinker hole. If the sinkers are a bit loose, hold them in place with a small amount of tape.
6. Stick the other end of one of the three dowel rods into the open end of the compression spring.
7. Set the G-meter on a table so that the dowel rod is horizontal and mark the position of the center of the sinker. This equals a 1-G environment. Temporarily attach one of the other pointers to the first and mark the 2-G position. Then do the same with the third pointer and mark the 3-G position. Remove the two extra pointers. Next, set the G-meter upside down and again mark the 1, 2, and 3-G

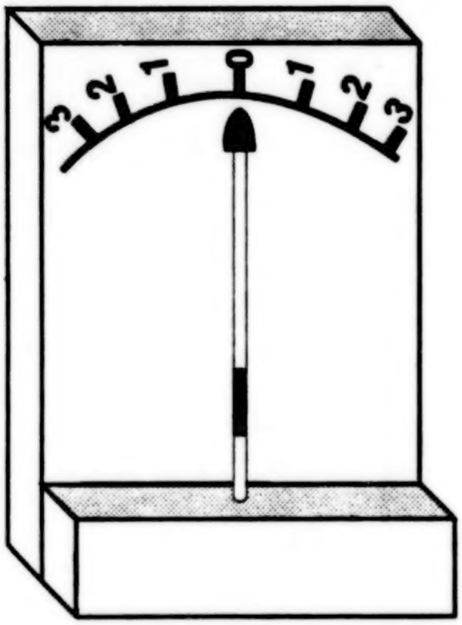
positions. Add minus signs to these marks for negative Gs. The G-meter is ready to use.

MEASURING G FORCE:

In addition to using this G-meter on a roller coaster or on an elevator (see companion activity - "Vertical G-Meter") the horizontal/ vertical G-meter can be used to measure the G forces in a car as it accelerates away from an intersection or makes a fast stop. Hold the G-meter on its side. You will probably have to brace it against the side window to get the best measurements. When the car is at rest, the pointer will point straight up for 0-G. The pointer will swing back as the car accelerates forward and it will swing forward when the car slows down. In the vertical mode, this G-meter is held on its side and the pointer points to the 1-G position. If the meter goes up suddenly, the pointer will swing down. If the G-meter goes down suddenly, such as the holder steps off a high diving board, the pointer will swing up to the negative G range.

DISCUSSION:

(Refer to the companion activity *Vertical G-Meter.*)



Horizontal Mode
at rest

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